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Marketing Research Report No. 475

MODIFIED PROTECTIVE SERVICES for Shipment of California BARTLETT PEARS

Tests in 1960 Season

U.S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Market Quality Research Division

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The Pacific Fruit Express Co., for assistance in obtaining icing records.

Washington, D. C. May 1961

MODIFIED PROTECTIVE SERVICES FOR SHIPMENT OF CALIFORNIA BARTLETT PEARS--TESTS IN 1960 SEASON

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SUMMARY AND CONCLUSIONS

1. Initial half-stage icing with replenishment at Roseville, Calif., reduced the temperature of pear loads from California origins by an average of 18 degrees. Most cars did not run out of ice until the third noon in transit, or slightly less than 1 day past Ogden, Utah. After running out of ice, the average rise in temperature was about 4 degrees per day. Allowing the car to run for a period without ice is desirable with early pears to keep temperatures within a range favorable to the initiation of ripening. Re-icing at Ogden reduced the temperatures too much, except in fruit that was very warm initially.

2. Early fruit having pressure tests above 19 pounds and initial temperatures below 75° F. required only one re-icing in transit between California and the New York City market. Re-icing at Chicago allowed about 4 days for the fruit to ripen. Delaying the icing until Marion, Ohio, shortened the ripening period at market to about 3 days and would be safe only with minimum-maturity fruit.

3. When the initial temperature was between 75° and 85° F. in such early fruit, two re-icings in transit were required. Re-icing at Council Bluffs, Iowa, and Marion, Ohio, or equivalent icing stations on other routes would provide desirable temperatures in transit.

4. When the initial temperature was above 85° F., such fruit also needed two re-icings, but the first should be moved ahead to Ogden.

5. Chicago shipments of early fruit with pressure tests above 19 pounds and initial temperatures below 80° F. required only the half-stage initial ice and replenishment at Roseville. No further re-icing in transit was necessary. Such fruit took almost 5 days to ripen after reaching market.

6. Midseason fruit with pressures below 19 pounds, moderately warm (75° F.) and shipped half-stage standard to New York City, had about the same transit temperatures as fruit shipped full-bunker standard refrigeration, effecting a saving of $31.49 per car.

7. Thermostatic control to maintain desired transit temperatures can be obtained in the "Cargotemp"[2] or mechanically refrigerated cars. The Cargotemp cooled the load rapidly to the thermostat setting with uniform layer temperatures. Small temperature differences were found between car ends in the single-bunker Cargotemp. Layer differences in temperature were greater and cooling was slower in the mechanical than in the Cargotemp car. Slight temperature differences between car ends were also evident in the mechanical car tested; however, all temperatures in these cars were sufficiently low to prevent overripening in transit.

8. Temperatures desirable for the initiation of ripening in shipments to New York lie between 55° and 60° F. Desirable temperatures for Chicago shipments are between 60° and 65°.

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[1] Dr. Harvey is principal plant pathologist and Dr. Uota is senior horticulturist at Fresno, Calif.; Dr. Ringel is plant pathologist at New York; and Dr. Smith is senior plant pathologist at Chicago, Ill.

[2] Use of the name "Cargotemp" is for identification only and does not constitute special approval or disapproval of this car in comparison with others of similar design.

BACKGROUND

Research in the 1959 season on modified icing for rail shipments of Bartlett pears [3] suggested that one re-icing in transit would provide favorable temperatures for the initiation of ripening in early-season fruit. A series of shipping tests was conducted, therefore, to determine the relation of fruit maturity, initial fruit temperature, and modified icing practices to transit temperature and subsequent ripening of fruit at the market.

New types of railway equipment with thermostatic temperature control required tests to determine their effectiveness in maintaining desired temperatures for Bartlett pears.

Test shipments were made from the Sacramento River, Marysville, Placerville, and Lake County districts to the Chicago and New York marketing areas.

METHODS

Test cars were shipped in pairs (or three at a time) to compare the effects of various re-icing practices and railway equipment on temperatures in transit and on fruit ripening. All cars, except those that were mechanically refrigerated, were pre-iced before loading and, with one exception, were replenished at Roseville, Calif. All ice-bunker cars were iced to half-stage capacity with approximately 6,000 pounds of ice, except for one full-bunker car which received 11,500 pounds of ice. The paired cars were shipped on the same day to the same market and, whenever possible, by the same routing. Protective services, routings, and other test conditions are shown in table 1. Icing records for the test cars are shown in table 2.

Three test packages of pears were placed in each car at the centerline, quarterlength position, in the bottom, middle, and top layers of the loads. These test packages contained Ryan recording thermometers. In cars in which there was a suspected variation in temperature between ends, test packages were placed in both ends of the car. The fruit used in the test packages for all cars in a particular test was from the same orchard lot to insure uniformity of samples. All test packages contained size-150 fruit.

Examinations of the test packages were made in either the New York City or Chicago Market Pathology Laboratory of the U. S. Department of Agriculture. The fruit was rated for firmness, color, and soluble solids at shipping point, on arrival, and at intervals while being held at 70° F. at the market laboratories. Firmness, measured with a Magness-Taylor pressure tester with a 5/16-inch-diameter plunger, was used as the principal index of ripeness in this test. Ground color was rated by comparing the color of the fruit with a Bartlett pear color chart issued by the California State Department of Agriculture with ratings as follows: No. 1, green; No. 2, light green; No. 3, yellow-green; and No. 4, yellow. Soluble-solids content of the test fruit was measured with a hand refractometer.

TESTS OF MODIFIED PROTECTIVE SERVICES FOR RAIL SHIPMENTS TO THE NEW YORK CITY MARKET

Early-Season Fruit (July 7) Shipped from Sacramento River District

Three pre-iced cars were shipped under half-stage refrigeration, replenished at Roseville, and re-iced once in transit. A comparison was made of re-icing of cars (designated as Pr-1, Pr-2, etc.) at Marion, Ohio (Pr-1); Chicago (Pr-2), or Council Bluffs, Iowa (Pr-3).

[3] Harvey, John M., Uota, M., Ringel, S. M., and Cook, F. L. 1960. Studies of Modified Protective Services for Rail Shipments of Bartlett Pears--1959 Season. U. S. Dept. Agr., Agr. Mktg. Serv. AMS-385, 12 pp.

TABLE 1.--Loading data, protective services, and routings of test cars of Bartlett pears shipped from California districts on indicated dates in 1960 season

Test car No.	Date 1960	District of origin	Destination	No. of crates in load	Protective services	Routing[1]
Pr-1	July 7	Sacramento River	New York	722	Pre-iced, half-stage, replenished, 1 re-icing in transit (Marion, Ohio)	SP, UP, IC, Erie
Pr-2	July 7	Sacramento River	New York	722	Pre-iced, half-stage, replenished, 1 re-icing in transit (Chicago, Ill.)	SP, UP, IC, Penn.
Pr-3	July 7	Sacramento River	New York	722	Pre-iced, half-stage, replenished, 1 re-icing in transit (Council Bluffs, Iowa)	SP, UP, C&NW, Erie
Pr-4	July 8	Sacramento River	Chicago	722	Pre-iced, half-stage, replenished, no further re-icing	SP, UP, C&NW
Pr-5	July 8	Sacramento River	Chicago	720	Pre-iced, half-stage, replenished, 1 re-icing in transit (Council Bluffs)	SP, UP, C&NW
Pr-6	July 12	Marysville	New York	720	Pre-iced, half-stage, replenished, 1 re-icing in transit (Marion)	SP, UP, C&NW, Erie
Pr-7	July 12	Marysville	New York	720	Pre-iced, half-stage, replenished, 1 re-icing in transit (Chicago)	SP, UP, C&NW, Erie
Pr-8	July 13	Sacramento River	New York	720	Pre-iced, half-stage, standard refrigeration--Cargotemp thermostat 55° F.	SP, UP, IC, Erie
Pr-9	July 13	Sacramento River	New York	722	Pre-iced, half-stage, replenished, 1 re-icing in transit (Chicago)	SP, UP, C&NW, Erie
Pr-10	July 13	Sacramento River	New York	720	Mechanical refrigeration, thermostat 55° F.	SP, UP, IC, Penn.
Pr-11	July 14	Sacramento River	Chicago	722	Pre-iced, half-stage, replenished, 1 re-icing in transit (Council Bluffs)	SP, UP, CMStP&P
Pr-12	July 14	Sacramento River	Chicago	608	Pre-iced, half-stage, no replenish, 1 re-icing in transit (Council Bluffs)	SP, UP, IC
Pr-13	July 20	Marysville	New York	720	Pre-iced, half-stage, replenished, 2 re-icings (Ogden and Marion)	SP, UP, C&NW, Erie
Pr-14	July 20	Marysville	New York	720	Pre-iced, half-stage, replenished, 1 re-icing in transit (Chicago). Car held overnight with precooling motors on.	Sac. North. WP, UP, C&NW, Erie
Pr-15	Aug. 11	Placerville	New York	722	Pre-iced, half-stage, standard refrigeration	SP, UP, IC, Penn.
Pr-16	Aug. 11	Placerville	New York	722	Pre-iced, full-bunker, standard refrigeration	SP, UP, IC, Penn.
Pr-17	Aug. 23	Lake County	New York	720	Pre-iced, Cargotemp (1-bunker) thermostat 45° F.	NWP, SP, UP, IC, Erie
Pr-18	Aug. 23	Lake County	New York	720	Mechanical refrigeration, thermostat 45° F.	NWP, SP, UP, IC, Erie

[1] Rail lines abbreviated in accordance with the Official Railway Guide, National Railway Publication Co., New York.

TABLE 2.--Icing record for test cars of Bartlett pears shipped from California districts in 1960 season

Test car No.[1]	Days from loading to unloading	Ice added						Estimated ice remaining[2]	Total ice melted	Estimated ice used to refrigerate load[3]
		Before loading	After loading				Total			
		Pre-ice	Replenish	Re-ice						
				First	Second	Third				
		Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Pr-1	6-3/4	6,000	5,200	6,000	--	--	17,200	2,000	15,200	13,700
Pr-2	6-3/4	6,000	4,400	6,000	--	--	16,400	300	16,100	14,100
Pr-3	6-3/4	6,000	4,200	6,000	--	--	16,200	empty	16,200	14,200
Pr-4	5	6,000	4,800	--	--	--	10,800	empty	10,800	8,800
Pr-5	5	5,800	3,800	5,800	--	--	15,400	No record	--	--
Pr-6	6-1/2	6,000	4,800	6,000	--	--	16,800	200	16,600	14,100
Pr-7	6-1/2	5,800	3,600	5,000	--	--	14,400	600	13,800	11,300
Pr-8	7-3/4	6,000	5,900	[1] 1,400	[2] 2,700	[3] 2,400	22,900	5,850	17,050	14,800
				[4] 1,200	[5] 3,300					
Pr-9	8	6,000	4,800	6,000	--	--	16,800	3,150	13,650	11,650
Pr-10	6-2/3	Mechanical refrigeration								
Pr-11	6	6,000	3,000	6,000	--	--	15,000	No record	--	--
Pr-12	4-1/2	6,000	--	6,000	--	--	12,000	No record	--	--
Pr-13	6-1/2	6,000	5,200	4,800	6,000	--	22,000	250	21,750	17,750
Pr-14	6-1/2	6,000	2,400	6,000	--	--	19,800	750	19,050	17,050
			[4] 5,400							
Pr-15	6-1/2	6,000	5,400	[1] 5,000	[2] 5,500	[3] 3,400	25,300	3,750	21,550	19,550
				[4] 3,800						
Pr-16	6-1/2	11,500	6,000	[1] 7,500	[2] 5,600	[3] 4,400	38,600	8,350	30,250	25,250
				[4] 3,600						
Pr-17	7-3/4	7,000	[5] 4,000	[1] 2,700	[2] 4,000	[3] 3,600	26,400	6,100	20,300	17,800
			2,400							
				[4] 1,500	[5] 1,200					
Pr-18	7-3/4	Mechanical refrigeration								

[1] See table 1 for test car protective services, etc.
[2] Based on an estimated 75 pounds ice meltage per inch below hatch opening in each bunker.
[3] Estimate based on calculation of 1 ton ice meltage per day in empty car before loading.
[4] Ice added at packing house, car on precooling track.
[5] Ice added at Santa Rosa.

Fruit temperatures were near 70° F. at time of loading and the fruit in the three cars cooled similarly as far as Council Bluffs (fig. 1). The cars ran out of ice about 1 day before reaching Council Bluffs, and temperatures increased slightly during this period. Temperatures in the car re-iced at Council Bluffs remained between 52° and 58° after the initial cooling period, and were at 55° at the end of the trip. Fruit temperatures in the car re-iced at Chicago showed slightly greater fluctuation but remained below 60° and had a final temperature of 51°. In the car that was re-iced at Marion, the average temperature rose to 62° before the re-icing and fell to 59° by the time the car arrived at market. All three cars remained above 50° for the entire trip, and so were in a temperature range conducive to the initiation of ripening.

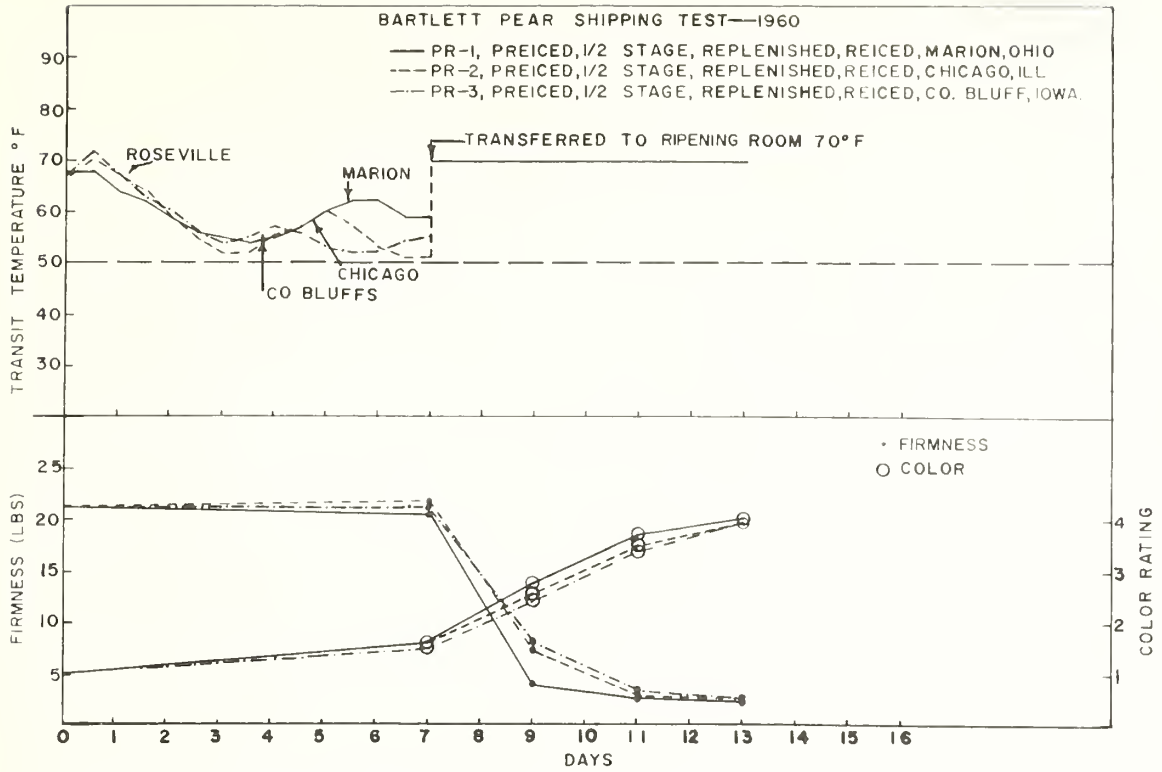

Figure 1. --Transit temperatures, firmness, and color ratings of early-season Bartlett pears shipped from the Sacramento River District of California to New York, N. Y., July 7, 1960.

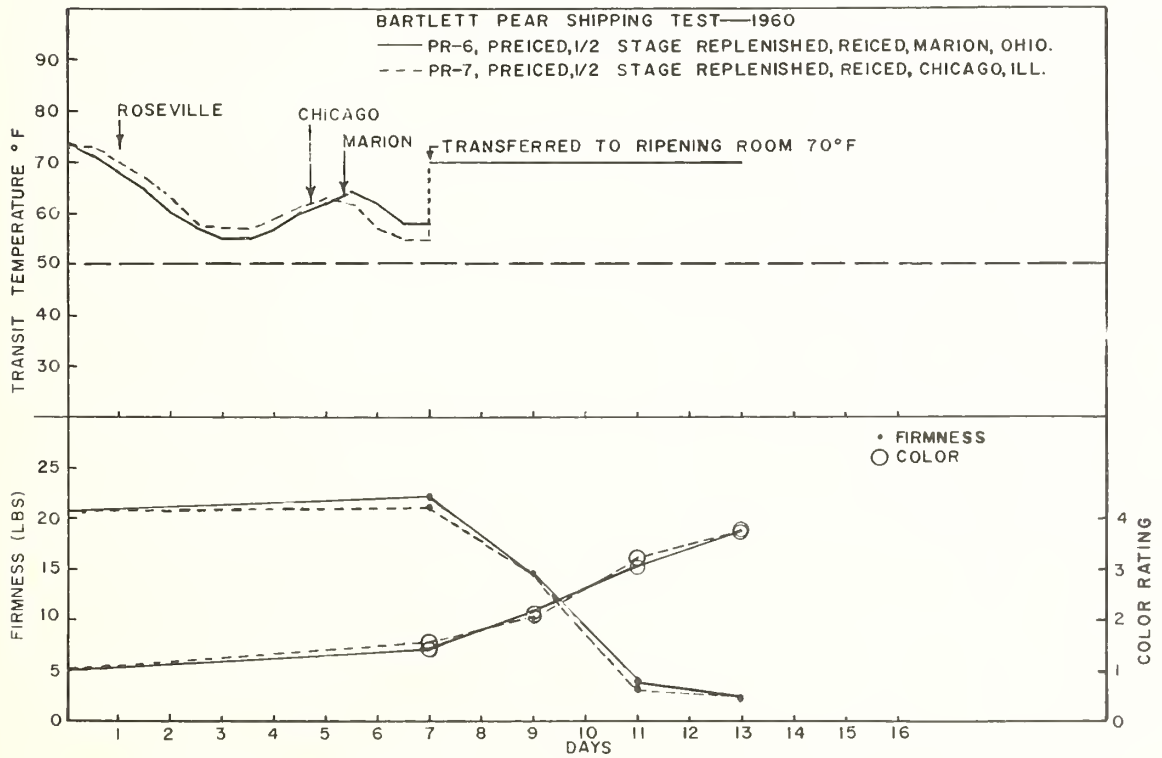

Figure 2. --Transit temperatures, firmness, and color ratings of early-season Bartlett pears shipped from the Marysville District to New York, N. Y., July 12, 1960.

Firmness of the fruit from the three cars was about the same on arrival (fig. 1), but decreased most rapidly thereafter in that from the car in which re-icing was delayed until Marion. Fruit from this car required about 3 days to reach an eating-ripe stage, while that from the other two cars took 4 days.

Color of the fruit in all three cars was rated 1.0 at time of shipment and increased to about 1.5 at arrival (fig. 1). Fruit from the car re-iced at Marion colored slightly faster than that from the other cars and reached the "color break" (3.0 rating) in about 2-1/2 days. Fruit from the other cars reached the color break in about 3-1/2 days.

Average soluble solids at harvest were 11.2 percent and on arrival were 13.7 (Pr-1), 13.2 (Pr-2), and 13.3 (Pr-3) percent. Averages when the fruit ripened were 12.8, 12.8, and 12.6 percent, respectively.

Early-Season Fruit (July 12) Shipped from the Marysville District

A comparison was made of fruit shipped in two cars pre-iced to half-stage capacity, replenished at Roseville, and re-iced either at Chicago (Pr-7) or Marion (Pr-6).

Fruit temperatures were about 73° F. at loading and fell below 60° in both cars after 2 days in transit (fig. 2). After reaching a low of 55°, fruit in the car re-iced at Chicago rose to 63°, then dropped to a final temperature of 55°. Temperatures in the car re-iced at Marion rose to 64° and had a final temperature of 58°.

Fruit firmness was about the same in both cars on arrival; neither softened in transit. The fruit in both lots ripened at about the same rate and reached an eating-ripe stage in about 4-1/2 days from arrival.

Color ratings of the fruit from both cars were about the same on arrival (1.5). The fruit reached the color break in about 4 days.

Soluble solids in the test fruit averaged 9.9 percent at harvest and 10.7 percent in Pr-6 and 11.4 percent in Pr-7 on arrival. Averages when the fruit ripened were 11.8 percent in both lots.

Midseason Fruit (July 20) Shipped from the Marysville District

Using very warm fruit shipped in two cars pre-iced to half-stage capacity and replenished at Roseville, a comparison was made between re-icing either twice in transit, at Ogden, Utah, and Marion, Ohio (Pr-13), or once in transit, at Chicago (Pr-14). The latter car also was held overnight with precooling motors on and ice was added at the packing house during precooling.

Fruit temperatures were near 83° F. at harvest and did not reach 60° in either car until they reached Ogden (fig. 3). Temperatures in the car that was precooled overnight decreased a little faster than those in the other car, rose to 66° before re-icing at Chicago, after which they fell to 59°. Fruit in the car re-iced at Ogden continued to cool to about 52°, and when the car ran out of ice, rose to 62°. The second re-icing at Marion brought the temperature back down to 55°.

Firmness of the fruit in the car with two re-icings averaged about 20 pounds on arrival, but that in the car with only one re-icing fell to about 16.5 pounds. Fruit in the former car took about 4 days to reach an eating-ripe stage and that in the latter car took only 2-1/2 days.

Fruit color on arrival had increased slightly, but was still below 2.0 in the lots in both cars. Fruit from the car re-iced twice in transit required about 3 days to reach the color break and that from the other car took slightly over 2 days.

Soluble solids at harvest averaged 10.7 percent in the test fruit, and on arrival was 11.5 percent in Pr-13 and 10.8 percent in Pr-14. Readings taken on the ripe fruit were 11.9 percent in both lots.

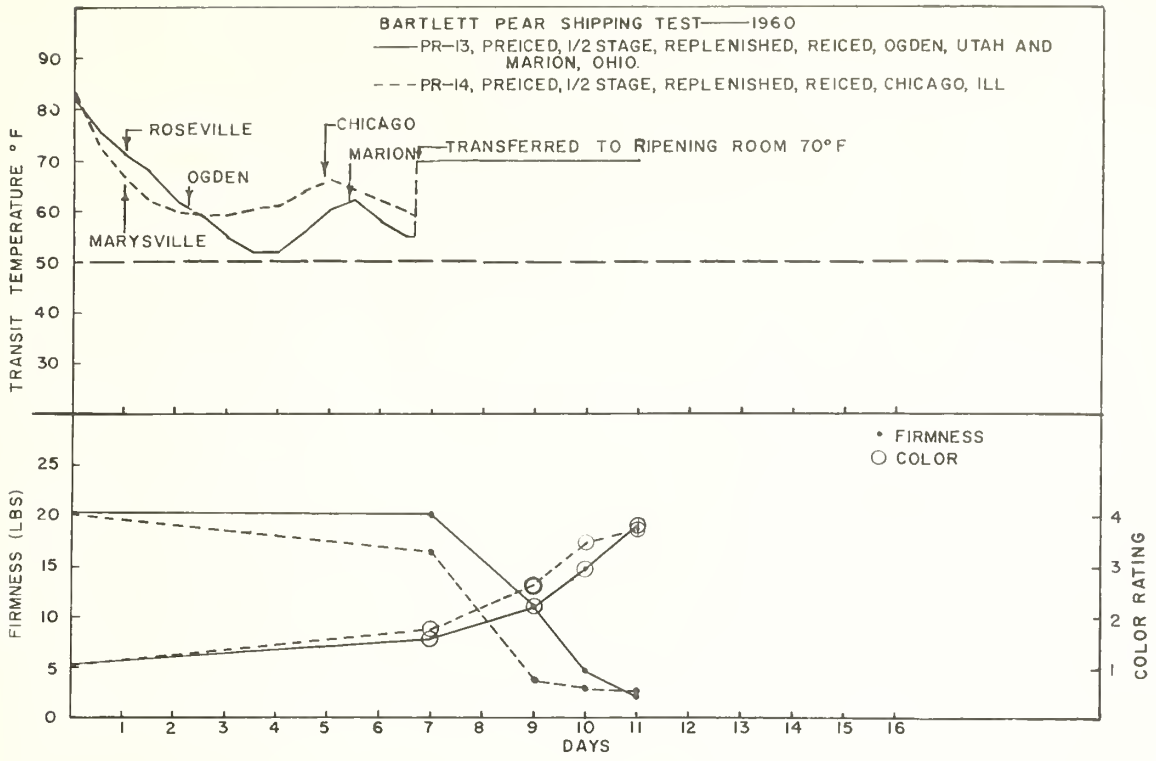

Figure 3. --Transit temperatures, firmness, and color ratings of midseason Bartlett pears shipped from the Marysville District to New York, N. Y., July 20, 1960. Pr-14 partially precooled with car fans at shipping point.

Midseason Fruit (August 11) Shipped from the Placerville District

A comparison was made between half-stage standard (Pr-15) and full-bunker standard (Pr-16) refrigeration, using moderately warm fruit in which initial firmness had dropped to about 18.5 pounds

Initial fruit temperatures were about 75° F. (fig. 4). The fruit in both cars cooled below 60° by the second noon in transit and below 50° on the third day. Transit temperatures were only 1 or 2 degrees higher in the half-stage than in the full-bunker car, and the final temperatures were 42° and 41°, respectively.

Firmness was just about the same in fruit from the two cars on arrival and at intervals during ripening. Both lots of fruit took about 5 days to reach an eating-ripe stage.

Color also was about the same in fruit from the two cars. Both lots of fruit reached the color break in about 4 days.

Soluble solids at harvest were 12.6 percent in the test lots, and on arrival were 14.1 percent in Pr-15 and 14.0 percent in Pr-16. When the fruit ripened, readings were 14.2 and 14.7 percent, respectively.

The icing charge for half-stage standard refrigeration to New York is $113.00 per car and for full-bunker standard refrigeration is $144.49 per car. The half-stage service saves $31.49 per car.

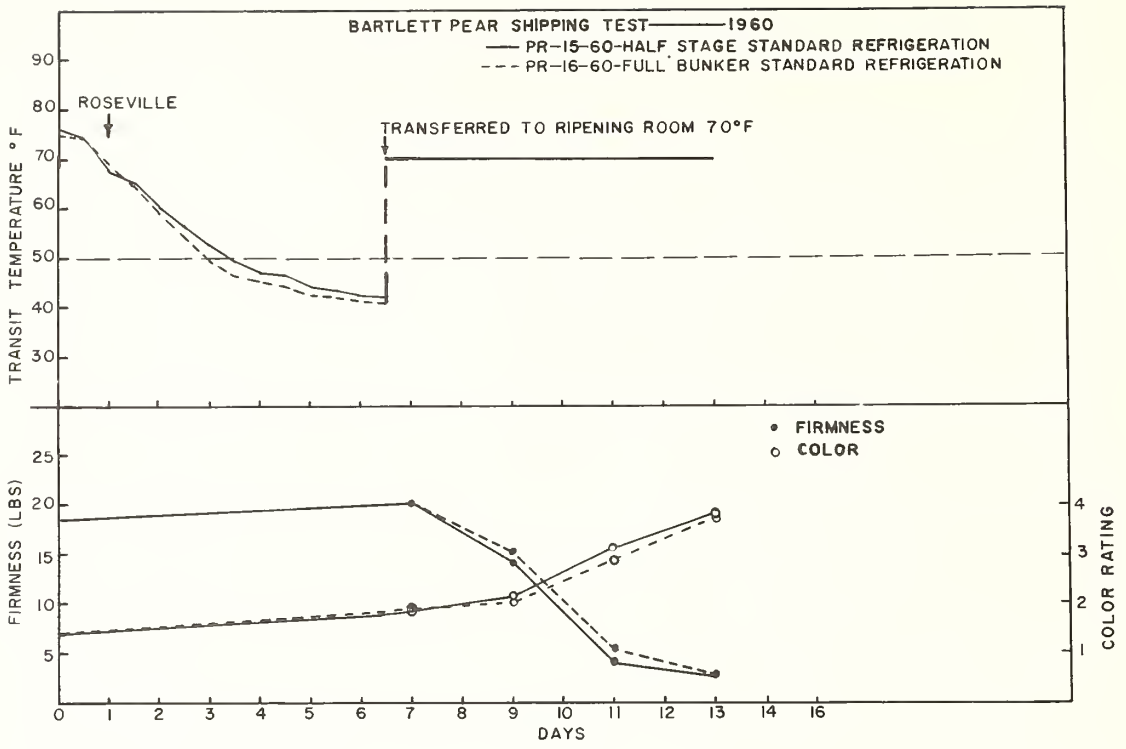

Figure 4. --Transit temperatures, firmness, and color ratings of midseason Bartlett pears shipped from the Placerville District to New York, N. Y., August 11, 1960.

TESTS OF MODIFIED PROTECTIVE SERVICES FOR RAIL SHIPMENTS TO THE CHICAGO MARKET

Early-Season Fruit (July 8) Shipped from the Sacramento River District

A comparison of no re-icing (Pr-4) and one re-icing in transit (Pr-5) was made in two cars that were both pre-iced to half-stage capacity and replenished at Roseville. The car shipped with one re-icing was re-iced at Council Bluffs, Iowa.

Temperatures of the fruit in both cars were near 70° F. at time of loading, and were similar in transit as far as Council Bluffs (fig. 5). Both cars ran out of ice about 1 day before reaching Council Bluffs, and the car that was not re-iced had final fruit temperatures of 59° when it reached Chicago. The car that was re-iced at Council Bluffs had a final temperature of 51°.

Firmness of the fruit on arrival was about the same in both cars and had not decreased in transit. During holding at 70° F., fruit from the car re-iced at Council Bluffs decreased in firmness more slowly than that from the other car, but reached an eating-ripe stage at about the same time--about 6 days after arrival.

Color ratings of the fruit from both cars were below 2.0 on arrival and the fruit required about 5 days to reach the color break.

Soluble solids in the test fruit averaged 11.5 percent at harvest and 11.6 percent in Pr-4 and 10.7 percent in Pr-5 on arrival. Average readings when the fruit ripened were 11.3 and 11.0 percent, respectively.

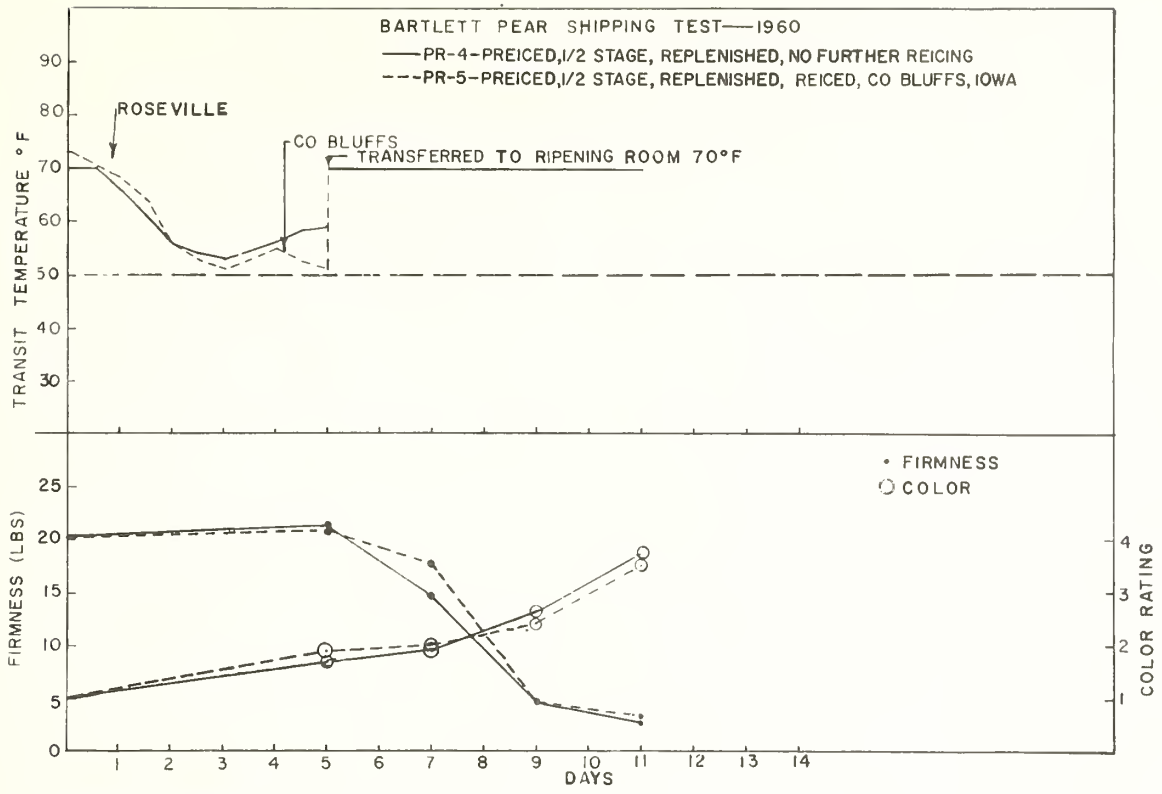

Figure 5.--Trahsit temperatures, firmness, and color ratings of early-season Bartlett pears shipped from the Sacramento River District to Chicago, Ill., July 8, 1960.

Early-Season Fruit (July 14) Shipped from the Sacramento River District

A comparison was made of two cars shipped with half-stage icing, both re-iced at Council Bluffs, but one replenished at Roseville (Pr-11) and the other (Pr-12) shipped without replenishing. Two test lots of fruit with slightly different maturities were placed in each car.

Initial fruit temperatures were almost 80° F. in both cars (fig. 6). In the car that was replenished at Roseville, the fruit temperature dropped to below 60° by the third midnight in transit, and almost to 50° after re-icing at Council Bluffs. The final temperature on arrival at market was 54° in this car. Fruit temperatures in the car that was not replenished did not fall below 65° and rose to 73° before re-icing at Council Bluffs. The final temperature in this car was 66°. The car shipped without replenishing was unloaded 1 day earlier than the other car.

Firmness of the fruit in both test lots and from both cars on arrival was near the original firmness. Fruit from the replenished car took about 4 days to reach an eating-ripe stage and that from the other car took almost as long. If both cars had been in transit the same length of time, differences in ripening would probably have been more apparent.

Color ratings of fruit in both lots and from both cars was near 1 on arrival. That in Test Lot 1 took about 3 days to reach the color break and that in Test Lot 2 took about 2 days in the replenished car, and 3 days in the car that was not replenished.

Soluble solids at harvest were 11.6 percent in Lot 1 and 10.8 percent in Lot 2. This difference may account for the slightly faster ripening in Lot 1 than in Lot 2.

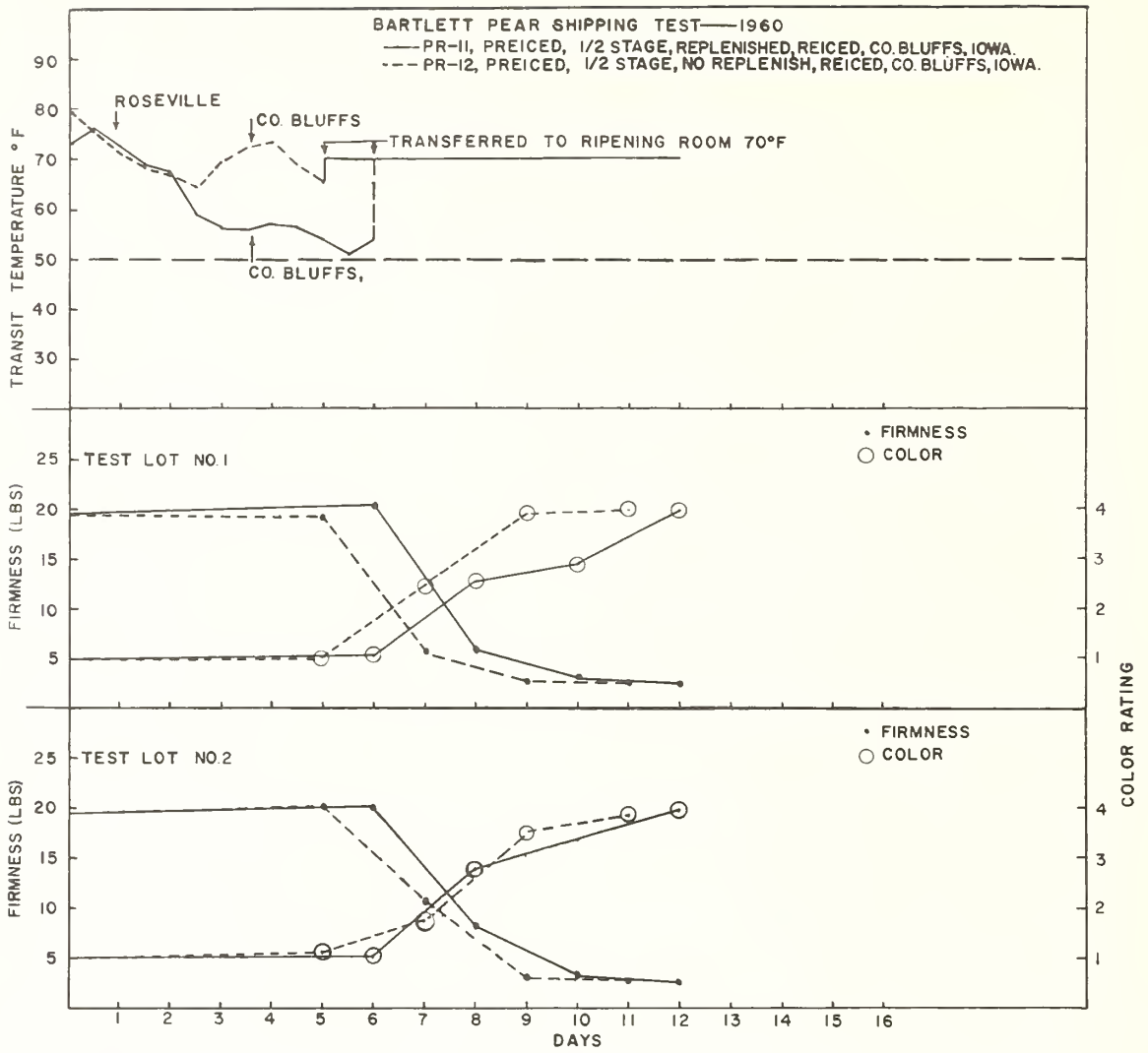

Figure 6. --Transit temperatures, firmness, and color ratings of early-season Bartlett pears shipped from the Sacramento River District to Chicago, Ill., July 14, 1960.

TESTS WITH RAILWAY EQUIPMENT WITH THERMOSTATIC TEMPERATURE CONTROL

Early-Season Fruit (July 13) Shipped From the Sacramento River District to New York City

This test was made to determine transit temperatures in various types of railway equipment. The cars tested were the "Cargotemp", a mechanically refrigerated railway car, and a conventional car pre-iced to half-stage capacity, replenished at Roseville, and re-iced once at Chicago.

The Cargotemp car (Pr-8) was a modified ice-bunker car that was equipped with a small diesel engine to operate the fans whenever refrigeration was needed. Movement of refrigerated air through the ice bunkers was controlled by thermostatically activated fans and louvers. An additional fan in each end of the car continuously circulated the air within the load compartment.

The mechanically refrigerated car (Pr-10) used in this test was of the semi-envelope design and had an air circulating system that discharged cooled air from a plenum at the ceiling which was perforated, allowing approximately 20 percent of the air to blow down

on top of the load. About 80 percent of the refrigerated air passed down flues in the walls of the car to openings at the floor level. All return air was drawn from under the floor rack to the coil bunker. Thermostats in both the Cargotemp and mechanical cars were set at 55° F.

Temperatures in all three cars were about 70° F. at the time of loading (figs. 7 and 8). Fruit in the Cargotemp car cooled to below 60° by the first midnight in transit, and to the thermostat setting by the second midnight. Fruit temperatures settled at 53° and remained there for the rest of the transit period. Layer temperatures in this car were very uniform during cooling and for the entire trip.

Fruit in the mechanical car cooled to 60° F. by the second midnight and settled at about 56° to 57° by the third midnight in transit. This temperature was slightly above the thermostat setting of 55°. Layer temperatures varied about 4 degrees during cooling, but were quite uniform once they settled near the thermostat setting.

Not all fruit temperatures in the conventional car reached 60° F. until 40 hours from loading, but they fell below 55° before the car ran out of ice. Temperatures rose to 64° by the time the car was re-iced at Chicago. There was a great spread in layer temperatures during cooling and again at the end of the transit period. This car, however, was delayed in transit, which may account for the lack of uniformity of layer temperatures toward the end of the transit period.

Firmness of the fruit on arrival was about 19 pounds in the Cargotemp car, 18.5 pounds in the mechanical car, and about 14 pounds in the conventional car. However, fruit from all three cars took about 2 days after arrival to reach an eating-ripe stage. The mechanically refrigerated car was unloaded 1 day earlier than the other cars.

Color ratings on arrival were below 2.0 in fruit from the Cargotemp and mechanical cars, but were almost 2.5 in the conventional car. Fruit from the Cargotemp car took longest to reach the color break, about 2-1/2 days; that in the mechanical car about 2 days, and that in the conventional car about 1 day.

Ripening was more uniform in the Cargotemp and mechanical cars than in the conventional car. Fruit from the conventional car had pressures on arrival of 10.2, 13.0, and 17.7 pounds, respectively, in the top, middle, and bottom layers of the load. Average arrival pressures varied by only 2.6 pounds in layers of the loads in the other two cars.

Soluble solids at harvest averaged 10.9 percent and on arrival were 13.0 percent in Pr-8, 13.2 percent in Pr-9, and 12.2 percent in Pr-10.

Midseason Fruit (August 23) Shipped from Lake County District to New York City

A comparison was made of transit temperatures in a single-bunker Cargotemp car (Pr-17) and in a mechanically refrigerated car (Pr-18), both with thermostats set at 45° F. In this Cargotemp unit, one of the ice bunkers was removed, to provide increased loading space, and the fan capacity of the remaining bunker was raised so that air movement was similar to that in the two-bunker Cargotemp. Since both cars in the test had their refrigeration supply at only one end of the car, test packages and thermometers were placed at the quarterlength in each end to determine how uniform the temperature was.

Fruit temperatures in the Cargotemp car were quite uniform in different layers of the load, but varied a little from one end of the car to the other (figs. 9 and 10). Fruit temperatures at the quarterlength position in the "A" end, which was farthest from the ice bunker, reached the thermostat setting after about 3 days in transit. At the quarterlength in the "B" end, where the ice bunker was located, temperatures dropped to 45° F. after 2 days in transit. Temperatures held at about the thermostat setting in the "A" end, but dropped to almost 40° in the "B" end.

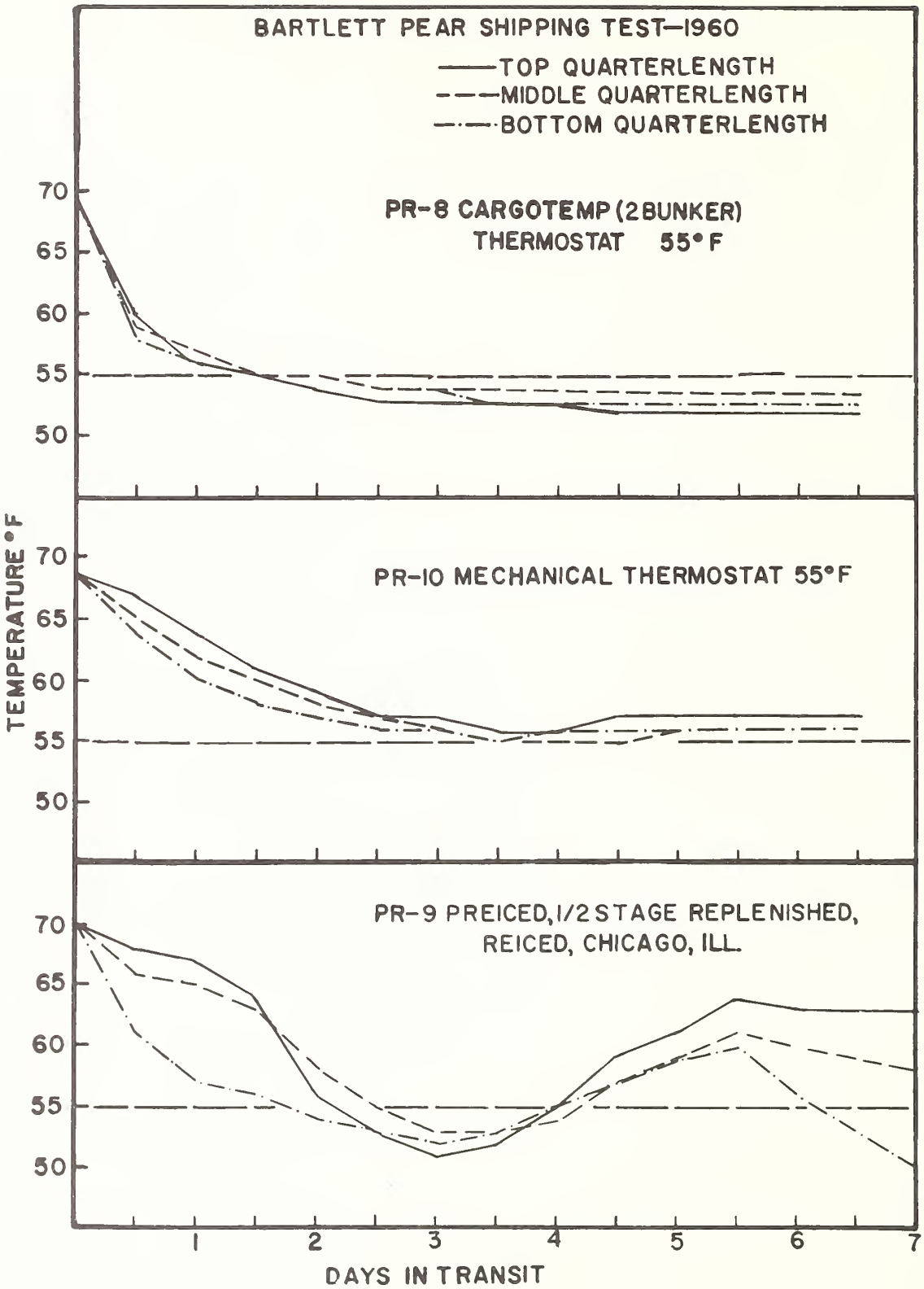

Figure 7. --Transit temperatures in the top, middle, and bottom layers of loads of Bartlett pears shipped from the Sacramento River District to New York, N. Y., in a Cargotemp, mechanically refrigerated, and conventional ice-bunker car, July 13, 1960.

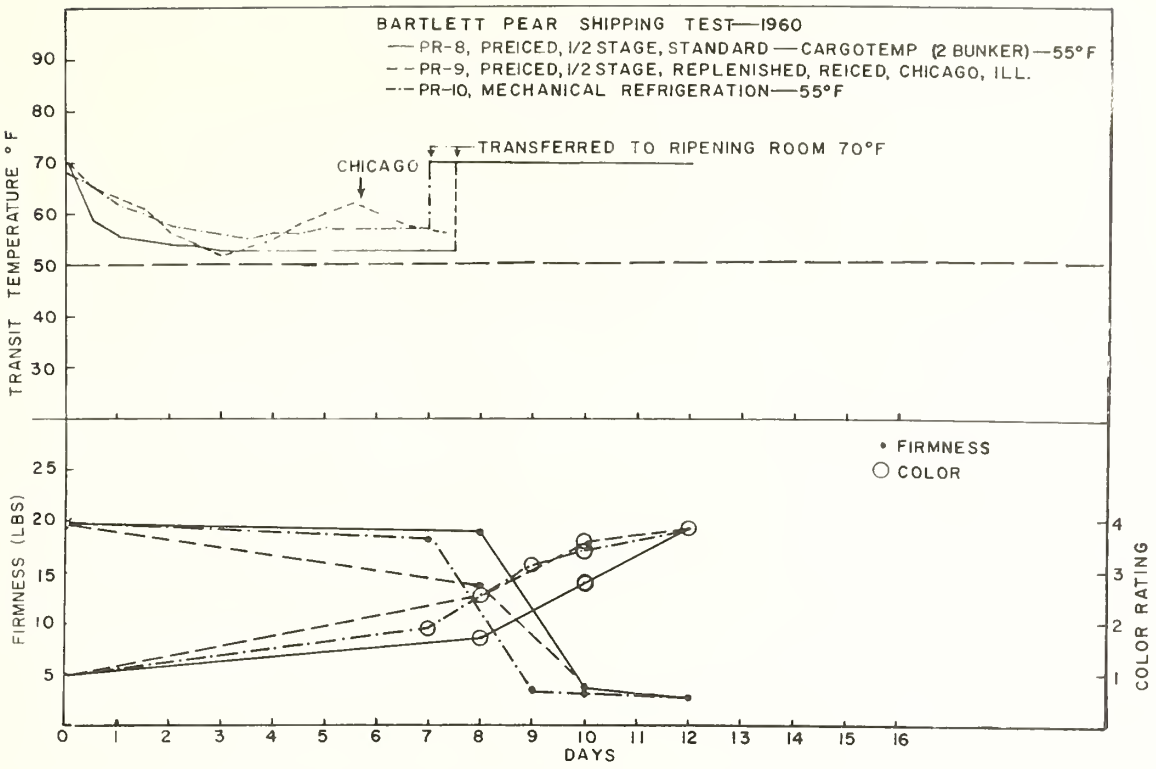

Figure 8. --Transit temperatures, firmness, and color ratings of early-season Bartlett pears shipped from the Sacramento River District to New York City, July 13, 1960.

Fruit temperatures in the mechanical car varied slightly between layers during the cooling period (figs. 9 and 10). Cooling was slightly faster in the "A" end, where the refrigeration coil was located, than in the "B" end, and remained slightly above the thermostat setting. The "B" end took about 4 days to level off at about 50° F., somewhat above the thermostat setting. The recording thermometer at the bottom, quarterlength position in the "B" end failed to function.

A comparison of average temperatures in each end of the cars is illustrated in figure 10. Temperatures were low enough in both cars to prevent much ripening in transit.

Firmness of the fruit was about 18.5 pounds at time of packing and almost 20 pounds on arrival. The fruit from both cars took about 4 days after arrival to reach an eating-ripe stage. That in the "B" end of the mechanical car ripened a little sooner than the other lots.

The color rating was about 1.5 at harvest and 2.0 on arrival. The fruit required about 3 days after arrival to reach the color break, except in fruit from the "B" end of the mechanical car (warmest location) which took only 2 days.

DISCUSSION

Temperature reductions in pear loads following the initial icing and the replenishing at Roseville were remarkably uniform (table 3). They ranged only from 16 to 20 degrees and averaged 18 degrees, even though initial fruit temperatures ranged from 68° to 76° F in the cars in which this factor could be compared. The cars usually ran out of ice about 1 day past Ogden.

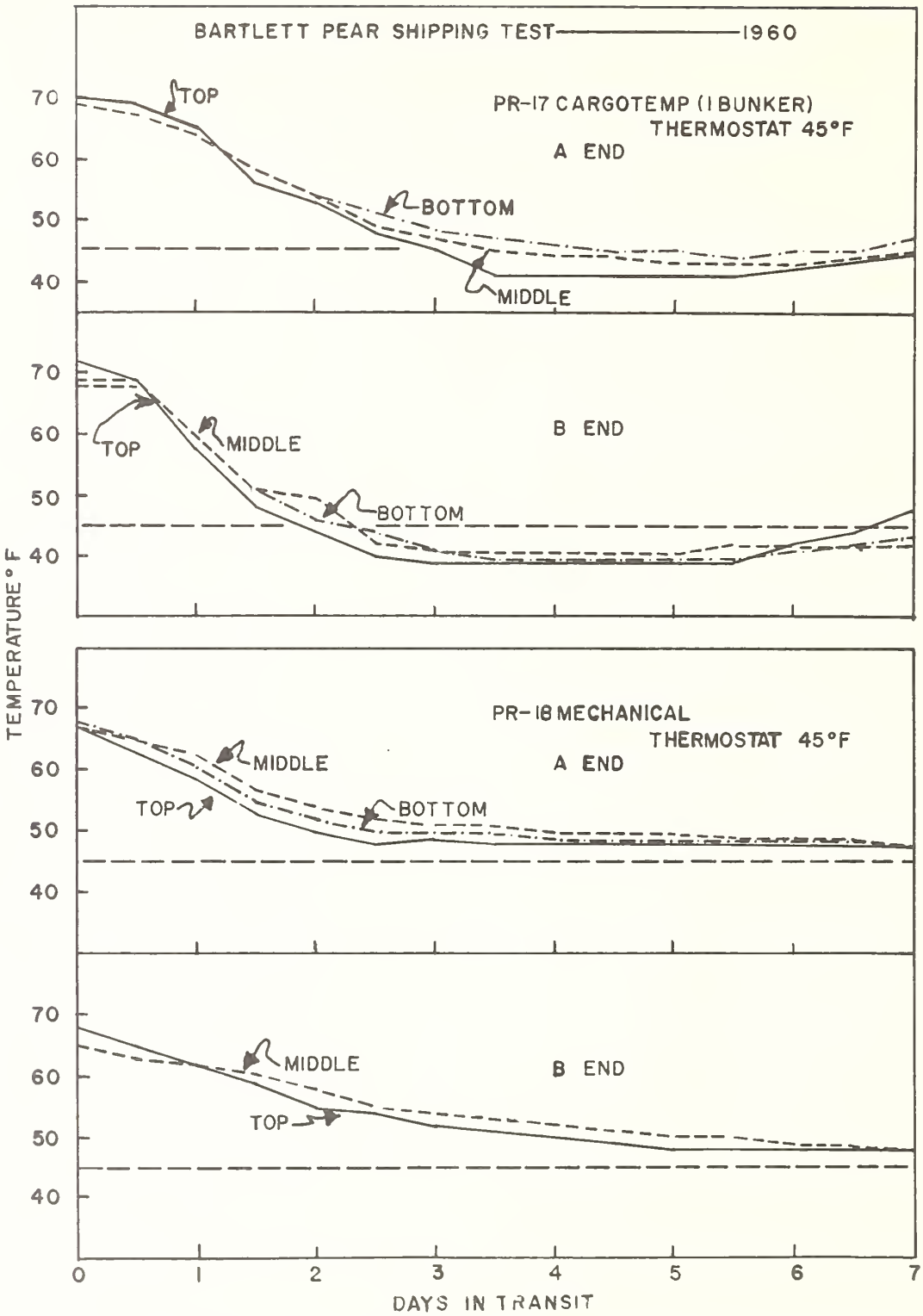

Figure 9. --Transit temperatures in the top, middle, and bottom layers of loads of Bartlett pears shipped from the Lake County District to New York, N. Y., in a single-bunker Cargotemp and a mechanically refrigerated car, August 23, 1960.

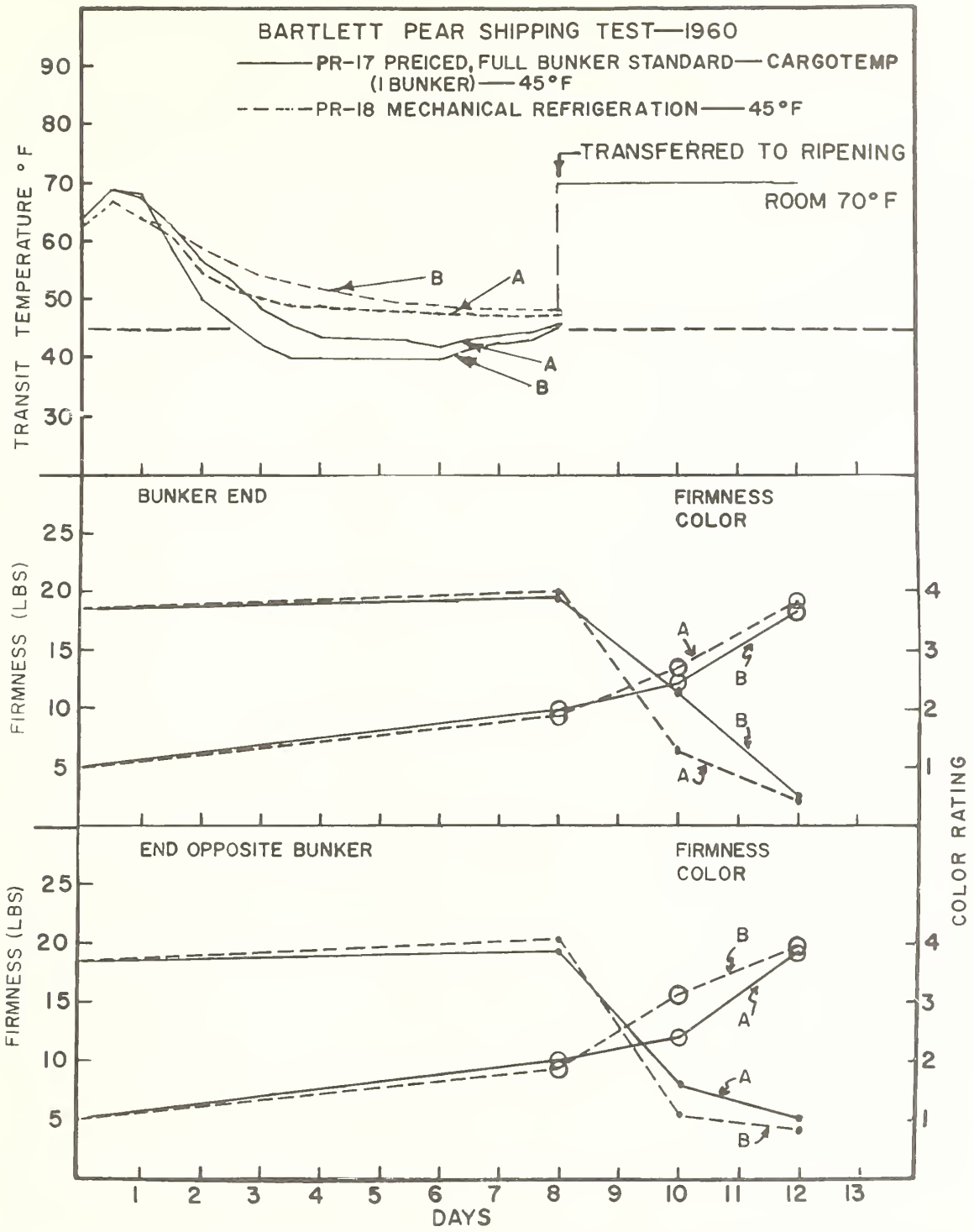

Figure 10. --Transit temperatures, firmness, and color ratings of midseason Bartlett pears shipped from the Lake County District to New York, N. Y., August 23, 1960; "B" indicates brake end of car and "A" indicates end opposite brake end; Cargotemp car has ice bunker in B end; mechanical car has refrigeration unit in A end.

TABLE 3.--Temperature reductions obtained from initial ice and replenishment of test cars and temperature rise after ice depletion in shipments of Bartlett pears from California districts in 1960 season

Test car No.[1]	Initial temperature of fruit	Temperature when initial and replenished ice depleted	Temperature reduction	Maximum temperature in transit after ice depleted	Time required to reach maximum temperature after ice depleted	Temperature rise prior to re-icing	Temperature rise per day
	°F	°F	Degrees	°F	Hours	Degrees	Degrees
Pr-1	68	54	16	62	48	8	4.0
Pr-2	70	52	18	60	36	8	5.3
Pr-3	71	54	17	57	24	3	3.0
Pr-4	70	53	17	59	48	6	3.0
Pr-5	71	51	20	55	24	4	4.0
Pr-6	73	55	18	64	48	9	4.5
Pr-7	73	57	16	62	48	5	2.5
Pr-9	70	52	18	62	60	10	4.5
Pr-11	76	56	20	--	--	---	---
Average			18				3.8

[1] See table 1 for protective services used with each test car.

Rises in temperature after the cars ran out of ice ranged from 3.0 to 5.3 degrees per day and averaged about 4 degrees (table 3.). The variation in individual test cars may be influenced by the rail equipment (insulation, fans, and general condition) as well as by outside temperatures.

Ripening data on early-season Bartlett pears indicated that desirable temperatures for New York shipments were between 55° and 60° F. These transit temperatures allowed about 3 to 4 days for the fruit to ripen after reaching market when held at 70°.

Knowing the temperature desired in transit, the average temperature reduction obtained with the initial ice and replenishment, and the average rise in temperature per day after the ice is depleted, one can gage the correct icing service in transit for a particular shipment. For example, if the initial temperature of the fruit were 75° F., the initial half-stage ice and replenishment would reduce the load temperature to about 57°. The ice in the car would be depleted about 1 day past Ogden, after which the temperature would rise about 4 degrees per day. Running without ice for 1-1/2 days would bring the load temperature to about 63°, so the car should be re-iced at Council Bluffs. The re-icing would bring the temperature close to 50°, after which it would start to rise again (see test Pr-3), but would not increase above 60° before reaching market.

If the initial temperature of the fruit were 85° F., the initial drop would bring the load only to about 67°. The first re-icing, therefore, should be moved ahead to Ogden to further cool the load close to 50°, and the car would probably run out of ice beyond Council Bluffs. Further re-icing would have to be delayed for about 2 days to bring the temperature to about 58°. Re-icing at Marion would provide desirable temperatures for the remaining time in transit.

The preceding calculations might be varied slightly according to the prevailing temperatures in areas through which the cars would pass.

The use of modified protective services for early-season Bartlett pears provides a practical means of initiating ripening in transit and thereby helps to avoid market gluts caused by excessively long times to ripen the fruit after arrival. Fruit maturity at harvest should be carefully watched, however, and when average initial pressures fall below 19.0 pounds, heavier icing should be specified.

Additional railway cars with thermostatic control of temperature are becoming available to shippers, and offer a means of controlling ripening in transit by merely specifying the thermostat setting. Temperatures are usually more uniform in these cars than in conventional cars. Cooling was faster in the Cargotemp than in the other types tested.

Refrigeration costs are greater in cars with thermostatic temperature control than in conventional cars shipped under a modified protective service. Mechanical cars are shipped under the standard refrigeration service ($144.49 to New York City) and the Cargotemp under the half-stage standard refrigeration service ($113.00), while the conventional car shipped pre-iced, half-stage, with replenishment and one re-icing in transit costs only $64.00 to the same market. An additional re-icing in transit brings the change to $82.00. Modified icing, therefore, offers considerable savings over the newer services with thermostatic control.

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